A Behavior-Based Management System
Safe Acts Index

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Abstract

Industrial process safety managers traditionally use aggressive safety awareness programs to maintain a safe environment. While they maintain an ongoing safety awareness program, managers initiate specialized safety programs when they deem that injury and accident rates are excessive. However, corrective programs, triggered by excessive injury or accident rates have the disadvantage of not being initiated after injuries or accidents have occurred. Thus, managers are interested in identifying leading indicators that would use measures of injury or accident potential so that they might trigger feedback actions before injuries and accidents occur. One such indicator is the Safe Acts Index (SAI).

This paper describes an implementation of the Safe Acts Index at a chemical plant. In addition, the paper provides a statistical analysis of the impact on safety, along with a conceptualization of the mechanism by which the SAI apparently modifies the employee risk acceptance.

Introduction

When we install a Performance Measure (PM) to assess performance of a system that includes one or more human "operators" (a broad interpretation of the term "operator" is used here to include all individuals who somehow influence the system operation directly or indirectly), we expect that the operators will adjust their behaviors in an attempt to improve system performance rating, as assessed by the performance measure. Installation of the PM may improve performance because it brings performance into focus and a common understanding of what constitutes superior and inferior performance. With a PM, all operators contributing to the system performance may be better able to pull toward the same goal. While we expect the operators to adjust their behaviors, we also understand that the skills presently available and efforts they are willing to make available may initially limit any performance improvement. Consequently, while we expect a change in system performance with the introduction of the PM, we cannot know beforehand the immediate and eventual impact on system safety. The issue then is how to install a PM and manage its use to insure a large initial improvement in system performance and a steadily increasing performance afterwards? The issue is the subject of this paper.

Since the system operators depend on the performance measure to guide their behavior adjustments in the search for ways to improve system performance, the performance measure itself must have certain properties. A necessary property is that the performance measure must assess each possible performance in a way acceptable to authorities, i.e., whatever the authorities ever consider superior performance, the PM must rate as superior. Whatever the authorities consider inferior performance, the PM must rate as inferior performance. Other performance measure properties include appropriate sensitivity, ease of use, consistent application and economical to use. For instance, considering sensitivity, the PM must detect each change in performance the authorities determine is a significant performance change. Nevertheless, if performance measure does not meet the primary performance discrimination property, the PM is not acceptable to the authorities and cannot be used. While this primary PM requirement seems obvious, users rarely test the performance discriminations of their performance measure. In fact, many PMs presently in use do not discriminate performance in any acceptable way, and worse, the users are unaware of the deficiency because the actual performance discrimination properties of the PMs have not been determined. Thus, a first step is the test of the PM to insure it satisfies this necessary condition. Connelly 1993 a,b gives a method of developing and testing industrial performance measures.

Events

An industrial accident, especially an accident with severe consequences, is an event demanding investigations of its causes and identification of possible cures. Examples of such events in industry and transportation are well known. One property of an event followed by an intense response is that it gets things done. Authorities improve aircraft maintenance procedures and equipment after aircraft accidents. They changed the type of procedures and training in nuclear plants after TMI. The chemical industry introduced new process safety management systems after several serious accidents in chemical plants -- to cite a few examples.

The follow up an event triggers, establishes the event importance. We can make an event important or not important as we want. For instance, news papers report car accidents involving multiple fatalities for a time and although auto accidents result in thousands of injuries and fatalities each year, they do not trigger as much attention as an aircraft accident. The Mothers Against Drunk driving (MAD) organization has shown how to change the response to accidents caused by drunk drivers by bringing broad and intense attention to the problem, resulting in a significant reduction in drunk driver accident rates. The point is that our response to an event defines its importance, and consequently, governs the attention drawn to it.

The concept is that we can define an event any way we want, depending on what we want to achieve. We can define an event in terms of human behaviors - such as the failure to adhere to safe work practice - directing attention to unsafe behaviors that will likely lead to accidents. Defining an event in terms of behaviors can potentially correct the problem before accidents occur rather than after, thereby improving the overall plant safety. Van Hamel, Connelly (1992) report an interesting example of this concept they found in use in a chemical plant. Information documented here is taken from that report.

The management safety system described here uses a performance measure assessing the degree of worker compliance to work safety standards. When the conformance level drops below the established criterion level, management announces that a safety "event" has occurred, triggering an intensive management feedback to the employees. This artificial event (and the associated management feedback) functions like a natural event, such as an injury or accident, in focusing attention to management's message. The intent is to replace accident events with artificial events defined in terms of measures of the degree to which safety behaviors are used. The rational is that if behaviors adhere to work safety standards, accidents will be avoided.

Safe Acts Index (SAI)

The Safe Acts Index is being used at both the corporate level and individual site (plant) level by a major chemical company which operates the plant discussed in this paper. Use of the index supports rapid feedback to supervisors and employees, and maintenance of a high state of adherence to work safety standards, reducing accidents and injures. Corporate level management periodically receives index data reports that provide a longer-term assessment of plant performance. The index is also used as part of periodic corporate audits of plants and for demonstrating commitment of corporate management to achieving and maintaining a high level of plant safety. In this paper we describe the Safe Acts Index and its successful use at a chemical plant.

The index is important for two reasons. One reason is that its use at the plant level substantially improves the proportion of observed acts performed safely at a plant that already has a high level of safety. The other reason is that it provides a leading indicator that enables corporate management to detect changes in plant safety "climate" and take appropriate action before accidents occur.

The Safe Acts Index is a measurement of the percentage of observed employee work acts performed safely. The plant safety manager observes employees at work during each work day, and records the number of observed acts designated to be unsafe and the total number observed. The safety manager uses a systematic procedure for observing workers to maintain as consistent a work sample as possible from week to week, and to distribute observations evenly across all work areas in the plant. Observed work acts are designated as safe or unsafe according to preestablished criteria to maintain consistency of the data.

At weeks' end, they calculate the index as the number of safe acts observed divided by the total number of acts observed, expressed as a percentage. They analyze index trends using a statistical process control method. If this analysis indicates that the "process", i.e., the safe performance of work acts, is out of control, then an unsafe condition is deemed to exist in the plant. This event triggers special safety feedback from management, designed to increase employees awareness of safety and to reinforce employee understanding of management's commitment to improving and maintaining a high degree of worker and plant safety. At the plant which was the subject of the case study, the feedback includes turning on flashing yellow "unsafe condition" warning lights in the plant, inserting messages on computer information screens, and other feedback from managers and supervisors. The rational for the use of the Safe Acts Index is that if all plant tasks, including operations, maintenance, engineering, administration, etc., are performed with a high degree of safety awareness, then accidents and injuries can be avoided.

The Safe Acts Index was installed at the plant in June 1987. Plant injury data were obtained from January, 1987 to March, 1988. This provided injury data for a five month period before the SAI was installed and 10 months after installation. Figure 1 shows the value of the SAI from Week 21 through Week 60. (Week 1 is the week ending January 25, 1987). SAI data cannot be shown prior to Week 20 because the SAI was not installed and the data were not collected. Note also that the SAI value for Week 20 is not plotted in the Figure. Its value for that week was 72% and it was omitted from the graph to permit a scale fine enough to show the small variations in the remaining SAI data. Obviously, the values that would have been calculated prior to implementation of the SAI are unknown; it is assumed that they were low, perhaps close to the initial calculated value of 72%. As seen from the Figure, the general pattern is a substantial increase in the SAI over the first eight weeks (subsequently referred to as the transient period), to an essentially steady state, although with some oscillation, at a mean value slightly above 98%.

Analysis

To determine whether the implementation of the SAI is significantly associated with a reduction in injuries, a comparison was made of plant injury rates before and after the SAI system was put into place. The injuries occurring before and after initiation of SAI use at the plant are shown in Table 1. Two cases are considered.

In the first case, the injury rates for Weeks 1-20, (before the SAI system was installed) were compared to the injury rates for the entire period after the system was installed (Weeks 21-60). In the second case, the rates before the system was installed (Weeks 1-20) were compared to the rates after the transient condition settled into the "steady state" condition (Weeks 29-60). The first eight weeks of SAI use are the transient condition in which the process was deemed as "out-of-control" according to a combined Shewart-CUSUM control scheme. Week 21 was the first week of use in which the process was considered as "in control", according to that control scheme. This second analysis compared the injury rate expected with the system in the long run (without transient effects) to the rates prior to SAI use.

The Mann-Whitney U nonparametric statistical test was used to test the hypothesis that the injuries prior (IP) to the use of the SAI and injuries with (IW) the use of the SAI were two independent samples from the same distribution. The alternative hypothesis was that IW was less than IP. Results shown in Table 1 clearly shows the injury rate was significantly lower with the use of the SAI.

A follow up conversation with plant personnel revealed that the SAI trajectory shown in Figure 1 actually contains two transients. One transient is the rapid increase in the SAI during weeks 20 through week 28, as noted previously. The remaining trajectory shown in the Figure is a slower transient leading ultimately to a 1.0 SAI (data for weeks after week 60 were not available).

Conclusions

The management response to the SAI event of dropping below the out-of-control threshold appears to work effectively. Evidence supporting this claim is the increase in the SAI after the event occurs and the feedback is triggered. Apparently the task of maintaining a high conformance to work safety standards is difficult to maintain, as evidenced by the SAI drift to out-of-control after a interval in control. Thus, the need to define the event to trigger the response appears to be necessary because the SAI does not remain at a high level but drops frequently to trigger the event. Apparently if the event were not triggered the SAI value would drop, presumably to the pre-SAI installation level. Based on the relationship between the SAI and the accident rate shown in Table 1, We would expect that the accident rate would significantly increase as the SAI decreases.

References

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Table 1 Statistical Analysis of Plant Injury Date

Condition	Mean Injury Rate	Level of Significance of Difference
Prior to use of SAI	1.10	
With SAI (including transient)	0.55	$p<.05$
With SAI (steady state)	0.38	$p<.001$

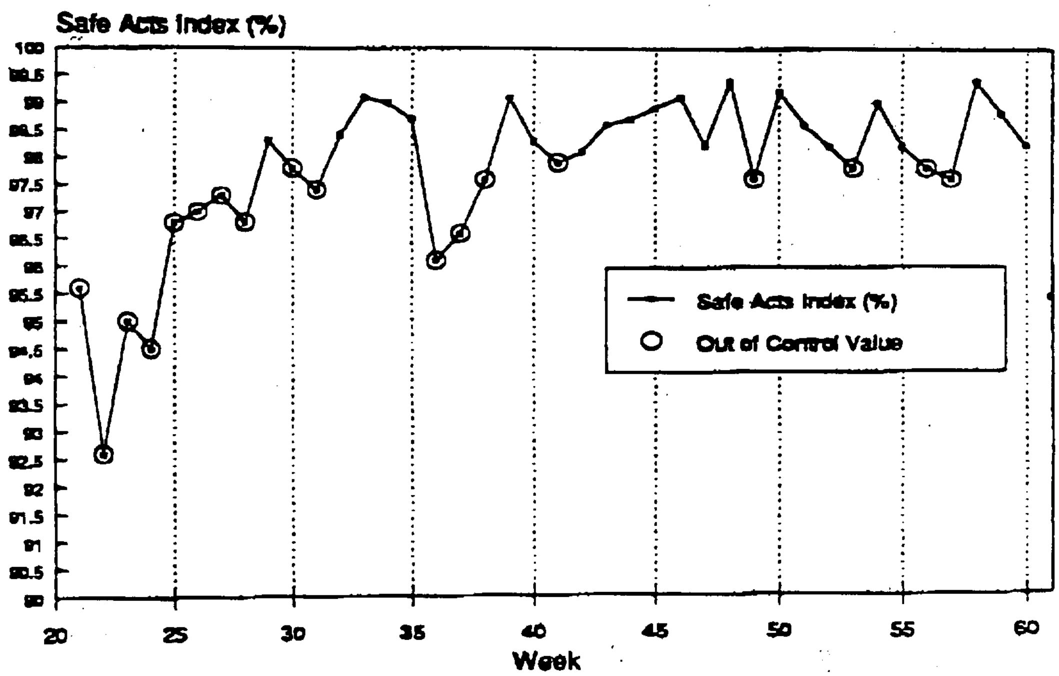

Figure 1 Safe Acts Index